DG – Interactive Geometry Package User Guide

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Overview

What is DG?

DG is a software package to visualize geometry on a computer and to let user investigate geometric drawings. It is an interactive learning environment created to illustrate school geometry course and to make it visual and easy to understand.

For students

As a student, you can use DG when learning geometry, to see what geometric figures are, easily discover properties they possess and measure anything about them with just one mouse-click. Imagine: instead of drawing the figure on paper and trying to guess what properties this figure has, you just draw this figure in DG with the help of a few mouse clicks – and then easily explore and discover things that would be difficult to see on paper.

Of course, DG can be used in a wide variety of ways, but the main goal of the package is to give you an ability to explore geometry on your own by carrying out experiments and to easily make discoveries. Perhaps you'll even find some fact new for the humanity (some discoveries were already made by students who played with DG!).

For educators

As a teacher, you could use DG for vivid presentations and demonstrations, creating rich visual illustrations that clearly show all the main moments and reveal the nature of relationships between figures.

It is aimed to help teachers of geometry and their students to make geometry learning more visual, interesting and comfortable.

General possibilities

- Modeling geometric constructions: performing construction with special computer tools equivalent to ruler and compass, exploring resulting configuration and carrying out measurements.
- Advantages of dynamic geometry: instant update of all dependent parts of the construction and measurements when user changes some basic parameters (drags a point).
- Creating live visual illustrations, interactive and dynamic learning materials, reference books and "expert systems", using comments, buttons, hints and hyperlinks.

- Organization of computer experiments and explorations, forming hypotheses and checking their plausibility.

Detailed possibilities and functions

DG allows to:

Carry out constructions, analogous to classic ruler-and-compass constructions:

- Draw points.
- Draw segments, rays and lines.
- Draw circles given their center and point on a circumference.
- Construct circles with given radius.
- Construct distances and angles equal to given.
- Draw parallel and perpendicular lines, bisectors.
- Construct points on figures.
- Find intersection points of figures.
- Find symmetric points and inverted points, draw segment midpoints.

Measure drawing parameters

For example distances, angles, areas, coordinates, etc. Measurements also update instantly when basic parameters change. This feature provides wide possibilities for explorations, search of regularities and patterns, and formation of hypotheses. Measurements can be carried out in three ways:

- Direct measurement via measurement tools (creation of measurement marks near object being measured).
- Adding a text label that contains a dynamic expression in brackets. In this way any correct mathematical expression will be evaluated and its result will appear in a label text.
- With the aid of built-in geometric calculator, which also allows to evaluate expressions.

Automate the process of construction…

… by means of defining a new tool – creating a macro.

Use elements of analytic geometry:

- Coordinate system, equations of lines and circles, algebraic dependencies between parts of a construction, function plots, etc.
- Specify figures and points analytically, i.e. given equations or functions for coordinates (5 types of line equation, 2 types of circle equation), especially analytic curves and function plots

Design and arrange a drawing

Edit visual properties of points and figures: names, color, draw width and transparency, hide auxiliary elements, lock elements.

Locus

Construct locus of a point (geometric place of points), trace the point as it moves, configure loci appearance, and construct dynamic loci.

Buttons

Create interactive elements - buttons that allow user to show/hide objects, get hints, use multimedia and hyperlinks.

Construction playback

Replay construction algorithm step-by-step.

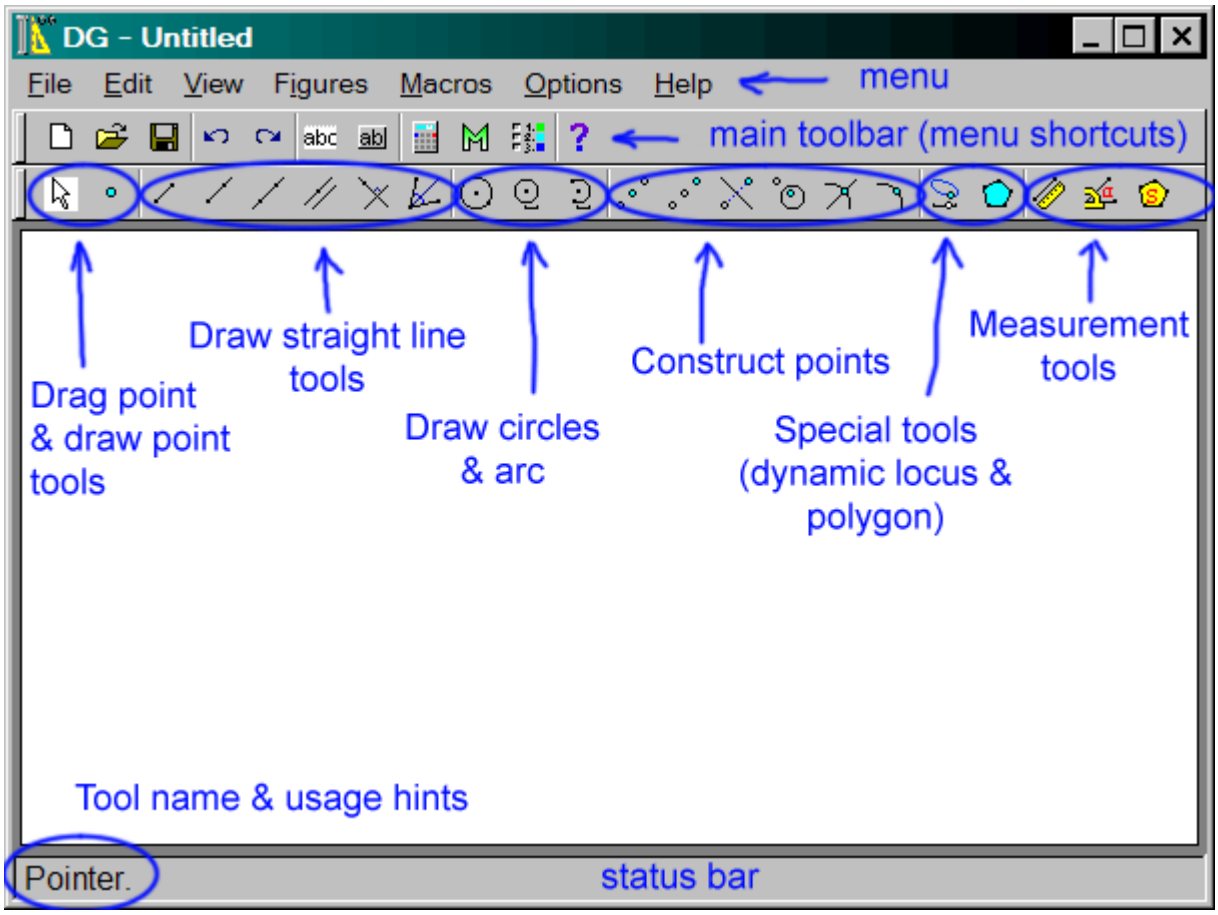
Drawing format

Export drawings to graphic file formats (BMP, EMF, WMF) to create geometric illustrations, export the drawing into Java Sketchpad (© 2001 Key Curriculum Press) HTML format.

Playing with the software

Interface overview

When you start DG, you see the main window. Here are some explanations:



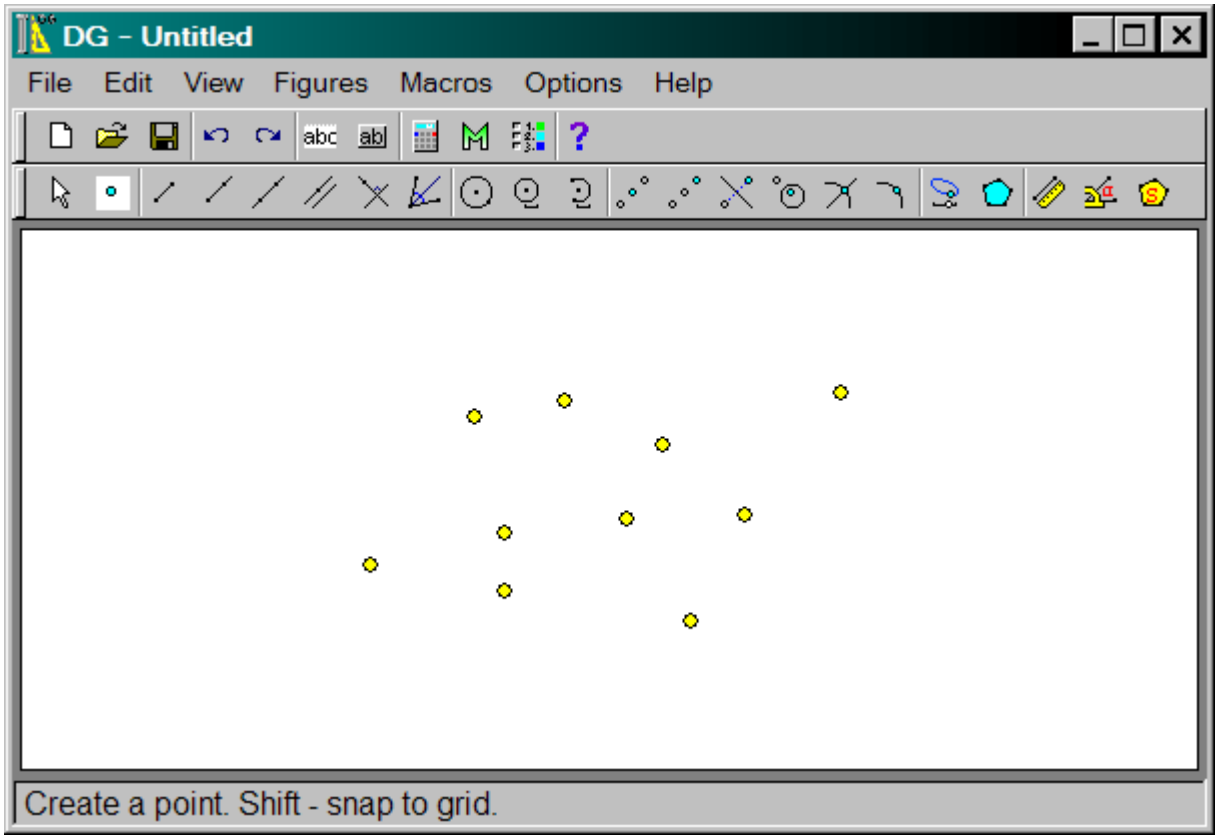
The most important elements are the geometry toolbar and the drawing (paper) itself.

Right-click any tool in geometry toolbar to see its description. If you need help while working in DG, just click F1. And don't forget to look at the status bar – useful tips are displayed there.

Basic constructions

Points

To draw points, you need to enable `Point` tool of the geometry toolbar. Now click anywhere in the drawing to create new points:



After you're finished, select the first tool of the geometry toolbar again (Pointer) to move (drag) the points.

Properties

Pay attention to the status bar when working with objects: useful tips are showing there depending on current active tool and location of the mouse pointer. For instance, try to see what happens when the active tool is `Pointer` and you position the mouse over a point.

You will get a hint: right-clicking the point shows a pop-up menu for this point. You can, for example, click `Properties` to edit its colour or size. You can experiment with the properties dialog to design your points and pick any colour, fill colour or size you wish.

Point list and figure list

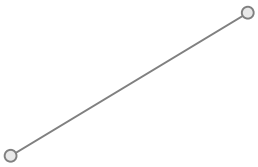
You can change the properties of several points at the same time by opening Point list window in menu "`Figures | Point list`". Select several points in the list of all points and change their attributes.

The same goes for the list of all figures. Use menu "Figures | Figure list" to assign common properties to several figures at the same time (for example, paint all lines blue instead of black or hide all circles). Please see online help for Point list window and Figure list window by pressing F1 when the respective window is open.

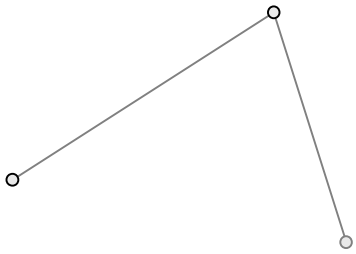
Let’s construct a triangle

We want now to construct three segments – three sides of a triangle. Let's activate `Segment` tool of the geometry toolbar. You can now construct a segment by clicking twice – first time to set its first endpoint, and the second time to set its another endpoint.

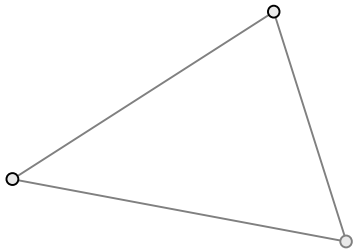
There are two possibilities to construct an endpoint: either clicking an already existing point or clicking an empty region of the drawing for a new point to appear there.



Ensure that `Segment` tool is still active. Let's now click one of the existing endpoints (which will become the first endpoint of the second segment), and then click where you want the third triangle vertex to appear. Thus you have constructed second side of the triangle.

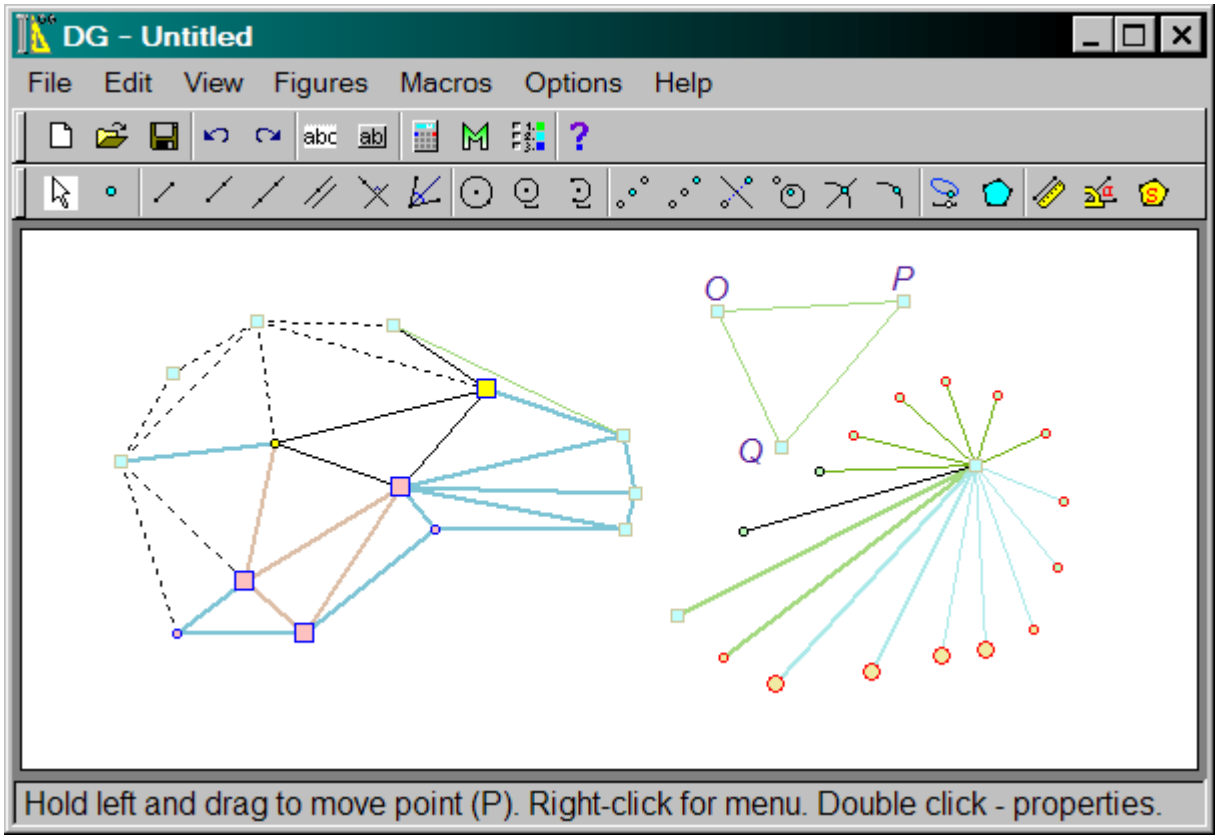


Finally, to construct third side of the triangle, click first point, and then third point, to connect them with a segment.



Now move the points! Don’t forget to make the `Pointer` tool active (you can do this quickly by pressing Escape key).

You can also construct everything you like: many triangles connected with each other, any points or segments, pick any colours and style. To change properties of a segment, right-click it and select Properties. Don’t worry to experiment, try out everything you like – be creative!



Polygons

We can also use `Polygon` tool to construct a triangle. To do this, first make the tool active by clicking its icon. Then left-click first vertex of the triangle (or empty area where you want it to appear), then left-click the second point (or empty area), and finally, click the third vertex (or the place where you want it to appear) with the **right** mouse button – to indicate that the polygon is already completed.

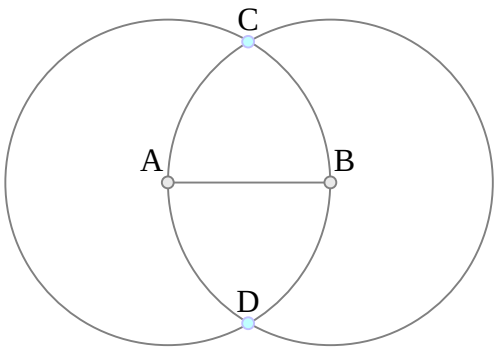
In this case, besides three vertex points and three segments, a triangle interior is drawn and painted with the solid colour. It is a polygon with three vertices. Click it with the right mouse button to access its context menu.

Experiment with points, segments and polygons! Try to move points (don't forget to make `Pointer` tool active! – you can do this quickly by pressing `Escape` key). Try also right-clicking these objects, configuring their properties and hiding them. To quickly display properties dialog for an object, double-click it.

Constructing an equilateral triangle by its side

Imagine that we have two points – A and B, and a segment that connects them. We want to construct an equilateral triangle ABC. That means constructing such a point C so that the resulting triangle ABC is equilateral (all its sides are equal).

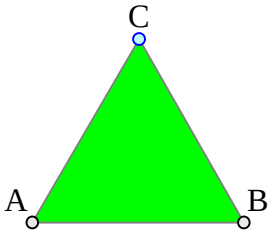
First let's activate `Circle` tool. Clicking point A and then point B constructs a circle with centre in point A and passing through point B. In the same way let's construct a circle centred at point B and passing through point A. By choosing `Intersection point` tool and clicking these two circles in any order we construct their two intersection points C and D.



Now it would be nice to hide unnecessary figures like these two circles.

Note: when any auxiliary construction is deleted, all the subsequent resulted objects are also deleted. To keep them, you can hide them. To hide a point or a figure without deleting it, it is necessary to right-click it and select `Hide` from the context menu.

Let's hide both circles and the unnecessary intersection point. Let's construct segments AC and BC. If it is necessary to fill the triangle, you can construct a polygon with vertices A, B and C.



Other examples

Online help

Please see DG online help for additional commented examples on constructing figures and using geometry toolbar.

Drawing library

The DG drawing library contains numerous samples of drawings that can be done in DG. You can use these as a base to construct your own drawings.

Features

This section describes the basic types of activities in DG and the corresponding features of the software. We begin with drawing figures and points, exploring, what objects do we have available in general, and then how to modify or delete objects.

Creating objects

Objects are everything you can put in your drawing. The most important objects are points and figures.

To create a point it is necessary to activate `Point` tool on the geometric toolbar and click where you want the point to appear. While `Point` tool is active, you can click again to get more points.

To create a dependent object, you must click all its required parents. For example, to construct a segment that connects two existing points, you can activate Segment tool and click two points in any order.

Another example: if we want to construct a line that is perpendicular to given segment and passing through a given point, we can select Perpendicular line tool, and click the given segment and the given point (in any order).

You need to have Pointer tool active to be able to drag points. You can only drag points that you constructed with the help of the Point tool. You cannot drag, for example, a midpoint of a line segment.

To find out how exactly a geometric tool works, right-click its icon and select What's this? from the popup menu.

Objects and tools

Object in DG is any part of a drawing that can be created by user – a point, a figure, a measurement, a label, a button, etc.

Objects are created with the help of tools (tools are just a way to create objects). Geometric tools are elements of geometric toolbar. Geometric tools create geometric objects – points, figures and measurements. Measurements are marks that appear on the drawing when one of the tools Measure distance, Measure angle and Measure area is applied. Figure is any object that can be created via geometric toolbar except for points and measurements.

Points and figures are main objects in DG that provide principal functionality, i.e. to create a ruler-and-compass drawing. After the drawing is complete, points can be freely moved by dragging them with the mouse, and the entire drawing will change accordingly, while preserving dependencies between parts of a drawing. This is the main principle of dynamic geometry. In such a way DG provides interactivity and ability to explore the drawing in dynamics.

Parent and child objects

When you construct a line segment, you first construct two its endpoints. A line segment always connects two points and cannot exist without them. You create a segment by defining two its endpoints. When you move an endpoint, the segment moves accordingly.

Generally, an object is called parental (or parent object) for geometric object A, if it was selected by user when creating object A. An object can have several parental objects. For example, parents of any segment are two points.

When you delete a parent object, all its children are deleted as well (because how should a segment exist without its endpoint?)

Free and dependent objects

Geometric tools are mainly divided into dependent and independent (or free). Dependent tools create dependent objects, while independent tools create independent (free) objects. Given object is called dependent if there is another object in the drawing that is parental for a given one. Otherwise an object is called independent.

When you drag a point, all objects that depend on this point, move accordingly.

Independent tools create basic (source) objects, which serve as a base and foundation of a construction. They don't depend on any other object and their position is fully controlled by the user.

Position of dependent objects is fully determined by already created objects, which means dependence on these objects. To create a dependent object it is required to select all its parental objects as required. For example, a Middle point is a dependent object and its position is determined by two points – parental objects for the middle point. These two points, in turn, can also be dependent and so on.

Free objects

A point is basic free (independent) object. Point can be drawn using  tool of geometry toolbar. A point (also called free point, or base point) is independent of other elements of the construction and its position is defined by user (user drags a point with mouse). Points are a basement for the rest of the construction, because all other geometric objects depend on points.

Beside points, only lines and circles given analytically (by equation) are independent.

Dependent objects

Almost all other geometric tools in DG are dependent. This means that user cannot change position of these objects directly.

Dependent tools can be divided into two groups: geometric figures and constructions of points.

Each of figures is defined by points and/or other figures. E.g. a segment will be defined by two its endpoints. Straight objects are segment, ray, line, parallel line and perpendicular line. Geometric figures (required parental objects are shown in parentheses) are:

- Segment (two points)
- Ray (two points)
- Line (two points)
- Parallel line (point and straight object)
- Perpendicular line (point and straight object)
- Bisector (three points)
- Circle (two points)
- Circle by radius (three points – two endpoints of radius and centre of the circle)
- Arc (five points – two endpoints of the radius, centre of the circle, arc beginning direction and arc ending direction)
- Polygon (a set of three or more points)
- Dynamic locus (two points)

Point constructions are:

- Middle point (two points)
- Symmetric point (two points)
- Reflected point (point and a straight object)
- Inverted point (point and a circle)

- Intersection point (two figures)

Note that these points are dependent, unlike free point!

Intersection points

To create intersection of two already constructed figures it is necessary to choose `Intersection point` tool and click those two figures. Then one or two intersection points of these objects will be added to the drawing, according to the figures' mutual disposition. The two figures are parental for their intersection points.

Note. When two circles or lines intersect there always are two intersection points, which however can be coincident, lie at infinity or not in the plane at all. There also may be a case (when two figures coincide) when there is infinite number of intersection points and picking two of them loses sense.

As follows from above, when DG intersects two figures, it always creates a pair of intersection points. Each of them can temporarily disappear when figures stop intersecting, but they remain existing. In some cases one of the points will never exist (like when intersecting two lines). In this case DG adds an underscore ("_") to the point name and makes it invisible. But there always exists a pair of intersection points, and deleting one of them causes deletion of another. Intersection points are always in pairs.

Other objects

A point, given analytically (an analytic point) is also considered construction of a point. This construction is available in menu `Figures | Analytic | Point`. See about creating a point given analytically.

It is noteworthy that objects `Vector` and `Bezier curve` are not geometric objects according to above definitions. That is why they aren't listed in the figure list. Polygons and dynamic loci are also not listed in figure list.

Point on figure

The only geometric object that is neither free nor dependent is a point that belongs to a figure – `Point on figure`. It possesses properties of both types of objects and hence is called semi dependent object. A figure point stays always tied to its parent figure – circle, arc, line, ray or line segment. User can change its position by dragging, but it moves in such a way to always remain on its parent figure. And vice versa, when its parent figure is moved, the figure point moves with it.

A base point can be converted to a figure point. For this, it must be dragged upon a figure. Then you can right-click on it and select appropriate figure name from the "`Snap to figure:`" menu.

A figure point, on the contrary, can be released (converted to a free point) by right-clicking it and selecting "`Release point`" from the popup menu.

Undo and redo operations

If you accidentally performed an action that you didn't intend, you can simply click `Undo` button of the main toolbar. DG will return to the previous state. For example, if you accidentally deleted the necessary point, it will be restored. Only the file operations, like open file or save file, cannot be undone. DG supports unlimited number of undo operations, that is, you don't have to worry when working in DG – all the changes you make are reversible. Keyboard shortcut key for Undo operation is `Ctrl+Z`.

When you pressed `Undo` and then suddenly change your mind, you can press `Redo` button to restore undone action.

Thus you can “travel in time”, going to the past of your construction with Undo button (Ctrl+Z) to see the history of your construction and then returning to the present with Redo button (Ctrl+R). It is sometimes amusing to press and hold Ctrl+Z in the middle of a complex construction, to see objects vanish in the reversed order. No panic! Just press and hold Ctrl+R and you will see all your objects to restore automatically in the same order you constructed them originally from a blank page.

Editing and deleting objects

Context menus

Almost every object on a drawing has its own properties and actions that can be performed upon this object. For example, a polygon has display properties (e.g. colour or transparency) and it has one action associated with it – it can be deleted. All such actions and properties associated with an object are gathered in a context menu of an object – a menu which appears when user right clicks an object.

Context menu for a point

Context menu for a point is as follows:

- **Point properties** – displays point properties dialog that can be used to control visual appearance of a point and much more.
- **Show name** – turns on or off point name display beside this point. Note: If this menu item is checked, point name can be moved in a small neighbourhood of a point.
- **Snap to figure** – this item is accessible only if current point is free point and is near some figure. Then selecting this item leads to point snap to a figure (free point becomes point on figure – one of the list of nearby figures).
- **Release point** – this item is accessible only for points on figure. Clicking this item makes a point on figure free, stops restricting point’s motion to a figure. The point becomes no more dependent on any figure.
- **Locus properties** – submenu to manipulate locus of a point:
    - Create locus – if this item is checked then point draws a trace during motion (a curve – polyline, that describes the trajectory of a point).
    - Clear locus – erases already drawn locus but doesn’t stop drawing. If the locus of a point is dynamic, then DG stops calculating it and deletes dynamic locus.
- **Hide** – hides a point, while not deleting it (point continues to exist and act, it only cannot be seen and edited). To show hidden point again, see Point list dialog.
- **Delete the point** – completely removes a point from a drawing. This command also deletes all dependent objects that depend on this point. For example, if you delete an endpoint of a segment, then segment itself will also be deleted automatically.

Context menu for a figure

This menu also shows itself after right-clicking on a figure. It contains the following items:

- **Figure properties** – displays figure properties dialog, where visual appearance of a figure can be changed.

- **Hide** – makes a figure invisible while leaving it active (figure continues to exist and act, it only cannot be seen and edited). To show hidden figure again, see `Figure list` dialog.
- **Delete the figure** – completely removes a figure from a drawing. This command also deletes all dependent objects that depend on this figure. For example, if you delete a segment, then all lines parallel and perpendicular to this segment, all intersection points of this segment with other figures, etc. – all will be deleted automatically.

Context menu for a label

For labels context menu has such items:

- **Label properties** – displays label properties dialog.
- **Recalculate** – if a label contains dynamic expressions, they are recalculated and the label text is updated.
- **Fix in-place** – if this item is checked the label cannot be dragged with mouse.
- **Delete the label** – removes the label from the drawing.

Context menu for a button

This context menu is as follows:

- **Button properties** – displays button properties dialog.
- **Fix in-place** – if this item is checked the button cannot be dragged with mouse.
- **Delete button** – removes the button from the drawing. If this button is of type "Show/hide objects" then all objects hidden with this button are redisplayed again.

Other objects

For other objects, such as polygons and Bezier curves, context menus have only two items: object properties and delete object.

Labels: a tool for comments and measurements

Overview

You can add a text comment to a drawing and position it in any part of the screen. Such texts are called labels in DG. Inserting labels can be very useful when designing a drawing, adding comments, remarks, hints, instructions, etc.

Labels have a very useful feature: you can insert a mathematical expression in brackets [ ] to any part of the label's text and it will be recalculated automatically (instead of expression in brackets its current value will be substituted). See the next topic (*Measurements and calculator*) for details.

Creating a label

A label can be inserted into the drawing by pressing `Enter`, clicking  button of the main toolbar, or selecting "`Edit | Insert text label`" menu item. In any case label properties dialog will appear, offering to fill in properties of the label such as text, font and colour. After the dialog is closed, the label will appear at the centre of the screen. It can now be dragged to any position.

Using labels

When created, a label can be left-dragged with a mouse. Right-clicking it will pop up a context menu that will offer to:

- Edit label properties, including label text
- Fix label in place, so that it cannot be dragged by mouse
- Delete the label

Label properties dialog can also be called by double-clicking a label.

Measurements and calculator

DG allows to measure different parameters of the drawing: lengths, distances, angles, areas, etc. There are three ways of measurement:

1. Measurement tools

There are three measurement tools: `Measure distance`  , `Measure angle`  and `Measure area`  .

These tools are located at the right side of the geometry toolbar. They allow to create special text marks that display current results of the measurements. For example, `Measure angle`  mark is created by clicking three points – first point lies at one side of the required angle, second point marks the vertex of an angle, and the third one belongs to the other side of an angle. When the measurement is created, a measurement mark appears on the screen which shows current value of an angle in degrees. Drawing a small arc that notifies the angle is optional and can be switched on or off).

After creating distance measurement or angle measurement, you can move it within a small neighbourhood of the object being measured by dragging it with the left mouse button. Right-click on a measurement mark displays context menu for this measurement, where you can change its properties or delete it. When the object being measured is changed or moved, the measurement updates automatically.

`Measure area`  adds a text label with a dynamic expression that displays the current area of a polygon or a circle. This label behaves just like any other label with an embedded dynamic expression.

2. Inserting a dynamic expression into the label text

This way of measurement provides much more possibilities and allows to measure not only distances, angles and areas, but also to evaluate arbitrary mathematical expressions (dynamic expressions) with miscellaneous measurement functions, like coordinates, polar angles, oriented angles, slopes, etc.

You can insert a dynamic expression into the label text by embracing an expression with brackets [ ]. Any correct mathematical expression inside [ ] will be calculated automatically. Its current value will be inserted instead of the bracketed expression each time the value changes. A label can contain any number of such dynamic expressions in any parts of the label text. However the brackets [ ] cannot be nested (which means each opening bracket [must be followed by a corresponding closing bracket] before another opening bracket [meets).

To simplify editing of mathematical expressions, label properties dialog has an expression entry panel, which resembles ordinary scientific calculator, but with geometric measurement functions included.

3. Calculator

DG has a built-in calculator, which can evaluate geometric values direct from the drawing and has also usual capabilities of a scientific calculator.

Calculator can be displayed by pressing F5,  button of the Main toolbar or selecting "`Edit | Calculator`" menu item. It has a text field for entering expressions in text form.

As you enter the expression, its result is displayed automatically to the right of the expression, as soon as the expression is correct. Like label properties dialog, calculator also has an expression entry panel.

If the expression contains measurements of geometric values and is correctly formed, a button "`Create a label to measure this expression`" becomes available. It creates a separate text label, which contains current text from calculator dialog as a dynamic expression in brackets.

An expression is a string of mathematical symbols: constants, numbers, operators and functions. DG understands a broad range of symbols all of which you can use in expression text. Values of distances, angles, areas and coordinates of points can be used together with standard mathematical operations and functions.

How to enter mathematical expressions in DG

You can use the following items while entering mathematical expressions in DG:

Constants:

- Usual numbers, like 0, 2, 5, 4.7, -2.11, -19 etc.
- PI – the great and beautiful p – the ratio of a 180° arc length of a circle to the radius of the same circle (approximately 3.14159265359)
- e – Napier base or the base of natural logarithms, approximately 2.718281828459.

Operations:

`+`	addition
`-`	subtraction
`*`	multiplication
`/`	division
`\`	integer division
`^`	power
`%`	remainder

Logical and comparison operators:

`And`	boolean "and"
`Or`	boolean "or"
`Not`	negation
`Xor`	exclusive "or" (Anti-equivalence)

=	equals
<>	not equals
<	less than
>	greater than
<=	less than or equals
>=	greater than or equals

Logical and comparison operators are only used in the first argument of the `If` function, e.g.:

`If(A.X>0 And AB>0, 1/A.X, 0)` - returns 1/A.X, if A.X > 0 and AB>0, else returns 0.

See other examples below.

Functions:

`sin(x)`	sine of x (here and later x is in radians)
`cos(x)`	cosine of x
`tan(x)`	tangent of x
`ctg(x) or cotan(x)`	cotangent of x
`asin(x) or arcsin(x)`	inverse sine of x
`acos(x) or arccos(x)`	inverse cosine of x
`atn(x) or arctg(x)`	inverse tangent of x
`acot(x) or arcctg(x)`	inverse cotangent of x
`exp(x)`	e^x (exponent), equivalent to `e^x`
`ln(x)`	natural logarithm of x (logarithm to base e)
`lg(x)`	decimal logarithm of x (logarithm to base e)
`log(a,b)`	logarithms of a to base b
`sqr(x)`	square root of x (the same as `x^(1/2)`)
`sgn(x)`	`1, if x>0;-1, if x<0; 0, if x=0`
`abs(x)`	|x|
`rnd`	random number in [0; 1]
`random(a,b)`	random number in [a; b]
`max(a,b,…,k)`	maximum of expressions a,...,k
`min(a,b,…,k)`	minimum of expressions a,...,k
`if(a,b,c)`	if condition a is satisfied, returns b, otherwise returns c
`rad(x)`	converts x to radians (same as `x*PI/180`)
`deg(x) or x°`	converts x to degrees (same as `x*180/PI`)

Geometric measurements:

AB or Dist(A,B)	distance from point A to point B
Angle(A,B,C)	angle ABC in radians (0 to PI)
OAngle(A,B,C)	oriented (0 to 2*PI) angle ABC (measured counter clockwise)
XAngle(A,B)	angle between a horizontal ray starting in point A and directed to the right, and a ray, starting in point A and passing through point B; the same as the slope of the line AB
A.X	X-coordinate of point A
A.Y	Y-coordinate of point A
Norm(A)	Distance from point A to the origin (polar radius)
Arg(A)	Angle between x-axis and a ray from the origin, passing through point A (counter clockwise, 0 to 2PI)
Area(A,B,C,...,N)	N-gon area. Polygon vertices are separated by commas. If only two points are specified, returns area of the circle centred at the first point and passing through the second point

Examples:

Distance between points M and N:

```
MN
```

Perimeter of triangle PQR:

```
PQ + QR + PR
```

Angle BCD in degrees:

```
Angle(B,C,D)°
```

Area of circle centred in point A and radius AB:

```
Area(A,B)
```

Area of triangle KLM:

```
Area(K,L,M)
```

Ratio of length of AB to sine of angle BAC:

```
AB / Sin(Angle(B,A,C))
```

Double product of lengths of MN and PN and cosine of angle between them:

```
2 * MN * PN * Cos(Angle(M,N,P))
```

Ratio of the longest side in triangle ABC to the shortest:

```
Max(AB,AC,BC) / Min(AB,AC,BC)
```

Product of coordinates of point A, if any of the coordinates is positive, else sum of the coordinates):

```
If(A.X > 0 Or A.Y > 0, A.X * A.X, A.X + A.Y)
```

Analytic geometry: coordinates and equations

Coordinate system

DG uses Cartesian coordinate system, where x-axis is directed to the right, y-axis is directed upwards, and the origin is usually at the centre of the window. Units are centimetres (as they appear on the screen; the drawing however can be zoomed in and out, shrinking or enlarging the unit).

Pressing F6 and F7 toggles display of coordinate axes and grid respectively. Analogous commands are both in the "View" menu and in the "Options" dialog.

Coordinates and equations

You can toggle display of point name and coordinates in point properties dialog. This dialog also displays coordinates of the point (that can be changed if the point is free).

An equation of a segment (ray, line, circle or arc) is shown in figure properties dialog for the corresponding figure.

"Figures | Analytic" menu allows you to create a point given its coordinates (given expressions for coordinates). These expressions can contain measurements that depend on already existing points.

For example, to construct a point that divides given segment AB in ratio 2:1, you can specify the following expressions for the point coordinates:

$$X = A.X + (B.X - A.X) * 2 / 3$$

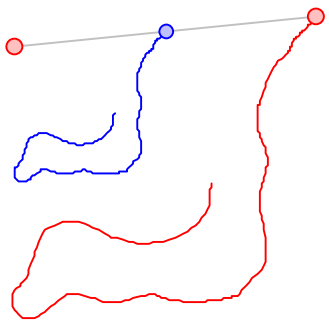
$$Y = A.Y + (B.Y – A.Y) * 2 / 3$$

In this menu you can also construct a line or a circle given its equation.

Locus: drawing and constructing curves

Locus of a point

Every point in DG can draw a trace when moving – a locus. For a point to begin creating a locus, it is necessary to right-click it and select "Locus properties | Create locus" in the popup menu. In this case a point will describe a trace – a curve (more exactly, a polyline). To stop drawing a locus, turn off the checkbox "Locus properties | Create locus" of the point context menu. Then you can turn the locus back on, again turn it off, etc.

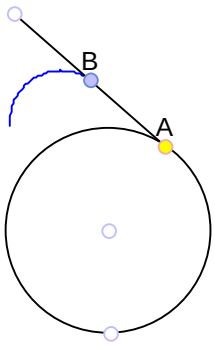


Locus properties (colour, line width and style) can be set in Locus properties dialog. There you can also toggle the locus, just like in the popup menu.

Locus can be deleted by selecting "`Locus properties | Clear locus`". However, this command doesn't stop creating locus if the checkbox "`Locus properties | Create locus`" is left on.

Dynamic locus

Let us now suppose that we have a point on figure, say point A on a circle. Let us also have a dependent point B that depends on point A. If point A moves around its parent circle, point B will describe some curve. To see it, you can create locus of point B as described in the previous topic.



But there is a possibility to automatically create a locus of point B as point A moves along its parent figure. It is dynamic locus. Dynamic locus is a tool for automatic construction of curves, which are a locus of some dependent point. The result of using `Dynamic locus` tool (in the Geometry toolbar) is a curve which automatically updates each time when parent figure moves. In our example, curve will update when a circle changes its radius or its centre is moved.

Creating dynamic locus

Dynamic locus depends on two parent points: point A, which lies on some figure F, and point B which depends on point A. To construct dynamic locus of point B when point A moves along its parent figure, it is necessary to select `Dynamic locus` tool , click point B and then point A. If these objects are properly defined, a curve will appear – a dynamic locus of point B.

In fact, dynamic locus is a geometric place of all possible positions of point B, when point A iterates all possible positions on its parent figure. Dynamic locus updates automatically when parent figure changes its position.

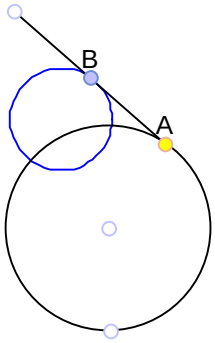
Appearance of locus and deleting locus

Dynamic locus properties can be accessed through context menu for the dependent point, just like as if it was usual locus of this point. Likewise, locus can also be deleted with the help of this menu.

Locus example

Let us have a circle centred at point F and passing through point G. Let point A lie on this circle. Let us also have point D, and point B which is the midpoint of segment AD. The problem is to construct a locus of point B when point A moves around the circle. In other words, we must construct a locus of midpoints of all segments with one fixed end, and another moving around the circle.

To construct a dynamic locus select tool and click point B, then click point A.



Note: If a point creates a dynamic locus, it cannot draw usual locus.

Macros: recording a construction for future playback

Overview

It is often necessary to repeat some steps of a construction several times, for example to construct three side bisectors of a triangle. Each construction takes several steps, and the steps for each side bisector are almost the same.

These steps can be selected out into a separate procedure and reused later. This procedure is called creating a macro. Macros are used to automate the creation process for some part of the construction. In our example, we note that we repeat following steps:

- construct a side midpoint
- draw a line perpendicular to the side and passing through its midpoint

Givens and results

Construction of a side bisector requires a line segment (the side). When we have a segment, we can construct its midpoint and the perpendicular line. Segment is what we need originally, and the perpendicular line (and a midpoint) is what we get as a result.

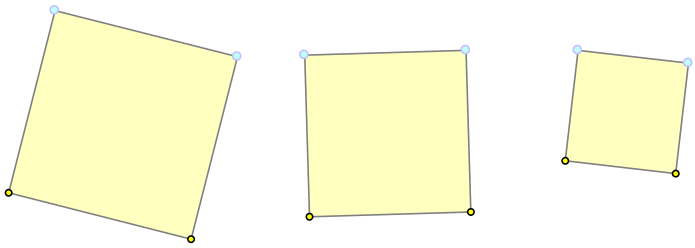
Generally, when you create a macro you select given objects (or simply givens) and resulting objects (or results).

When you use (apply or reconstruct) a macro, you just select necessary given objects, and DG constructs corresponding resulting objects automatically.

Given objects must precisely and uniquely define resulting objects, that is all resulting objects must depend only on those objects that were selected as given.

Example

For example, if you want to automate construction of the square defined by two its connected vertex points, you must select these two points as given objects and select all other vertices and edges as resulting objects. Then, in future, to create a square it will be enough to click two points and DG will reconstruct the rest of the square automatically.



Creating a macro

Macro creation process consists of the following steps:

Prepare a figure or a group of figures, for which you would like to automate the process of construction. Define for yourself, which objects this figure depends on, i.e. which minimal set of objects most conveniently defines the entire figure (group). You will have to select this or similar set of objects each time the macro is applied.

In "`Macros`" menu select the command "`Create a macro`", or click the button in the main toolbar. This will initialise macro creation process. "`Create a macro`" dialog will appear, inviting you to select given objects. If this dialog was turned off in Options, DG automatically jumps to selecting given objects.

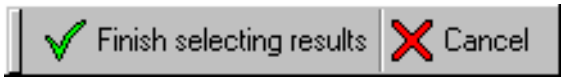
Selecting given objects

In "`Create a macro`" dialog, push the button "`Select given objects`". DG will switch to the givens select mode. Geometry toolbar will turn into given select mode toolbar:

In this mode it is necessary to select all given objects by clicking them and press "`Finish selecting givens`" in the toolbar. To cancel creating a macro press Esc or click "`Cancel`" button of the toolbar.

Selecting resulting objects

After selecting givens is complete, "`Macro result selection`" dialog will appear. If this dialog was switched off in Options, DG will jump right to the result selection mode. Otherwise you will have to press "`Select results`" button in this dialog to move to the result selection phase. Like in the previous step, DG will turn into result selection mode and the geometry toolbar will turn into special toolbar for this mode:



In this mode you need to select all required resulting objects and press "`Finish selecting results`" button of the toolbar. To cancel creating a macro press Esc or click "`Cancel`" button of the toolbar.

Note: all the intermediate objects, that results depend on, are also selected automatically into results, but they are hidden by default. For example, while creating a side bisector macro by two points, two points are selected as givens, and the perpendicular line is selected as the result, the segment and its midpoint are automatically included into macro results for the resulting macro construction to stay consistent, they only get invisible.

When selecting results is complete, “Finish creating a macro” dialog will appear, inviting you to specify new macro name and to save it.

Using a macro

To apply a macro that was created earlier, you have to load it (names of loaded macros are listed in Macros menu). To load or unload a macro, you can use “Macros | Organize macros” menu item, which will display “Organize macros” dialog. To quickly load a macro, use the “Macros | Load macro” menu item.

Steps to apply a macro are as follows:

- If the “Macros” menu doesn’t contain a required macro, choose “Macros | Load macro” menu item to locate the macro file on disk and load it (that is, add it into “Macros” menu).
- In "Macros" menu click the required macro name.
- Click needed given objects in sequence, that was defined during macro creation. Pay attention to the hints in the status bar. A type of next required given object is displayed there. To cancel applying a macro, press Esc.

Automatic loading of macros

You can select "Macro autoload path" in "Options | Misc". If you put the macro file (*.dgm) in “Macro autoload path”, it will be automatically loaded at program start-up (you won’t have to load it manually before use). This is useful for oft-required macros.

Step-by-step construction playback

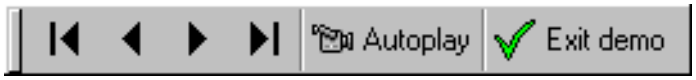
Construction playback overview

You can review the sequence of construction for the current drawing. It can be useful to demonstrate the algorithm of construction.

To set up options for construction playback (demo), use “View | Construction playback options” menu item. This will display construction playback set-up dialog.

Demo mode

To access the construction playback feature use “View | Step-by-step construction playback” menu item. When it is engaged, DG switches into demo mode. In this mode geometry toolbar turns into special demo control toolbar, which will somewhat remind CD-player controls:



This toolbar contains following buttons: jump to first step, previous step, next step, last step, automatic demo, exit demo mode and return to usual mode. Exiting demo mode is also possible with pressing Esc.

The whole demo is a sequence of construction steps. When a step is displayed, its number in sequence is shown in the status bar together with the total number of steps and comments to this step. A comment for a step can be manually edited in construction playback set-up dialog.

Controlling demo

Navigation is carried out with the help of demo toolbar buttons, or using keyboard:

- Enter, space, right arrow – next step.
- Left arrow, Backspace – previous step.
- Home – first step.
- End – last step.

Clicking left mouse button in the drawing will jump to the next step. Right-click in the drawing jumps to the previous step.

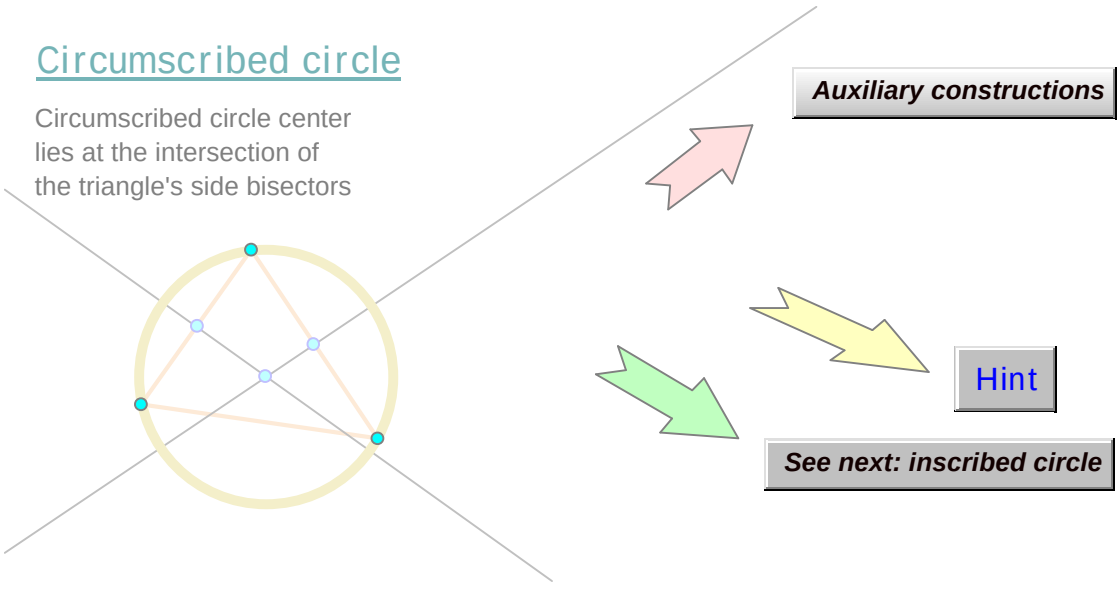
Auto play

Pushing “Autoplay” button of the demo toolbar turns on automatic jump to the next step with the specified delay. This delay (usually 1.5 seconds) is set up in construction playback set-up dialog. When autoplay is on, “Autoplay” button gets selected and a video camera icon is displayed in the upper right corner of the drawing. To stop automatic demo, push "Autoplay" button again:

Buttons: creating interactive drawings and hyperlinks

Button overview

You can add interactivity to your drawing by creating buttons. Buttons are located directly on the drawing and perform some specific action when clicked by user. Buttons can provide different functionality, for example, display or hide some elements of the drawing or open another drawing.



Creating buttons

A new button can be created by clicking "`Edit | Insert button`" menu item or pushing  button of the main toolbar. After this, button properties dialog will be displayed. After setting up all necessary properties in this dialog, click OK and a new point will appear at the centre of the drawing.

Using buttons

Left-clicking a button means a "push", and the button performs its action. Right-clicking the button pops up a context menu, from where you can choose to display button properties, fix it in place (restrict its motion) or delete it.

A button can be moved by right-clicking and dragging, which makes the difference for all other objects that can be dragged with the left mouse button.

Button types

There are four types of buttons. For their detailed description see help for Button properties dialog. A brief description of each type is displayed below.

Show / hide objects

This button displays or hides an arbitrary set of objects, which is defined in button properties. It is said that such button controls these objects. For each button you can choose its own list of objects. Moreover, a button can show or hide other previously created buttons. You can even arrange a "telescopic sequence" of buttons, by creating the last button in the sequence, then creating next button which controls this one, and so on.

You can create hints by specifying a label or labels for the button to control. Such button will display label text when pushed. This feature has powerful didactic possibilities.

Display message

This button display a message window when pushed. Message text can be edited in button properties dialog.

Play WAV sound

This button type plays a sound file in WAV format when pushed. A path and filename of the sound file is specified in the button properties dialog. If the file is located at the same folder as the active drawing, file path can be omitted (only the name needs to be specified explicitly). You can also specify relative paths, such as "`..\..\Sounds\Triangle.wav`".

Open a file

A button of this type opens an arbitrary file as if it was double-clicked in Windows Explorer. If the file is a DG drawing file, it is opened in the same window instead (current drawing will be closed).